

## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-110885

(43)Date of publication of application : 20.04.2001

(51)Int.Cl.

H01L 21/68

H01L 21/205

H01L 21/3065

(21)Application number : 11-291799

(71)Applicant : HITACHI LTD

(22)Date of filing : 14.10.1999

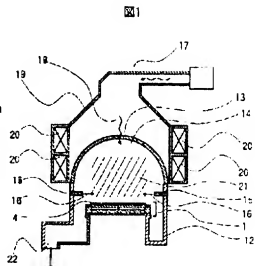
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## (54) METHOD AND DEVICE FOR PROCESSING SEMICONDUCTOR

## (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a semiconductor processing device comprising a sucking device wherein a semiconductor substrate can be pre-heated to a high temperature, with a sucking device excellent in response in temperature control, for an excellent process with a semiconductor substrate.

**SOLUTION:** Related to a semiconductor process device wherein a semiconductor substrate placement surface 5 comprises a sucking device 1 for holding a semiconductor substrate 4, a holding member 23 which holds the semiconductor substrate 4 on the semiconductor substrate placement surface 5 and a heat transfer gas chamber 26 wherein a gas is sealed between a holding member 23 and a cooling member 24 are provided.



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## CLAIMS

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[Claim(s)]

[Claim 1]An attachment component for holding a semiconductor substrate.

A cooling member for cooling.

A heat transfer gas room which is the semiconductor processor provided with an adsorber provided with the above, and can enclose and discharge gas between said attachment component and said cooling member was provided.

[Claim 2]The semiconductor processor comprising according to claim 1:

It is an electrode for adsorption to an inside of said attachment component.

A means to introduce gas between said semiconductor substrate and said attachment component.

[Claim 3]Claim 1 flowing a refrigerant into an inside of said cooling member, or a semiconductor processor given in 2.

[Claim 4]The semiconductor processor according to any one of claims 1 to 3 equipping an inside of said attachment component with a heating element.

[Claim 5]The semiconductor processor according to any one of claims 1 to 4, wherein said semiconductor substrate, said attachment component, said cooling member, and said heat transfer gas room have been arranged from a top in order of said processing body, said attachment component, said heat transfer gas room, and said cooling member.

[Claim 6]Temperature of said semiconductor substrate, temperature of said attachment component, and temperature of said refrigerant which flows into said cooling member, Have a means to measure at least one of said pressures of the heat transfer gas interior of a room, and using the measurement result Calorific value of said heating element, A pressure of a gas supplied between said semiconductor substrate and said attachment component, and temperature of said refrigerant in said refrigerant passage in said cooling member, The semiconductor processor according to any one of claims 1 to 5 which carries out feedback control of at least one of a flow of said refrigerant in said refrigerant passage in said cooling member, and pressures of said heat transfer gas room.

[Claim 7]A semiconductor process method comprising:

A process of adsorbing a semiconductor substrate on an attachment component which carried in a semiconductor substrate and built in a heating element in a processing chamber.

A process which supplies a gas between a semiconductor substrate and an attachment component, and raises a pressure.

A process of making a heating element inside an attachment component generating heat, and heating a semiconductor substrate.

A process which supplies a gas between an attachment component and a cooling member, and raises a pressure while generating plasma in a processing chamber, a process which extinguishes plasma and terminates membrane formation, and a process of taking out a semiconductor substrate from a processing chamber.

[Claim 8]A semiconductor process method comprising:

A process of adsorbing a semiconductor substrate on an attachment component which carried in a semiconductor substrate and built in a heating element in a processing chamber.

A process which supplies a gas between a semiconductor substrate and an attachment component, and

raises a pressure.

A process of making a heating element inside an attachment component generating heat, and heating a semiconductor substrate.

A process which supplies a gas between an attachment component and a cooling member which built in a refrigerant passage, and heating a pressure while making raw gas introduce in a processing chamber, a process which stops introduction of raw gas and terminates processing, and a process of taking out a semiconductor substrate from a processing chamber.

[Claim 9]When processing two or more substrates by repeating said each process continuously as 1 cycle in a semiconductor process method according to claim 7 or 8, A semiconductor process method changing exothermic quantity of heat of a process of making a heating element inside said attachment component generating heat, and heating a semiconductor substrate, for every processing cycle.

[Claim 10]When processing two or more substrates by repeating said each process continuously as 1 cycle in a semiconductor process method according to claim 7 or 8, A semiconductor process method giving a different pressure for every processing cycle in a process which supplies a gas between said attachment component and a cooling member which built in a refrigerant passage, and raises a pressure.

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[Translation done.]

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention]In the semiconductor process process of this invention starting a semiconductor processor and needing the temperature controlling of semiconductor substrates, such as a semiconductor wafer, especially, It is related with the semiconductor manufacturing device and disposal method which were provided with the adsorber which removes heat from a semiconductor substrate or heats a semiconductor substrate into the processing process.

[0002]

[Description of the Prior Art]Conventionally, in the semiconductor manufacturing process, in order to process semiconductor substrates, such as a semiconductor wafer, plasma-CVD (Chemical Vapor Deposition) equipment, a plasma etching device, etc. using reactant plasma are used. In these plasma treatment apparatus, the electrostatic adsorber is used widely. Hereafter, an electrostatic adsorber is explained according to drawing 7. The adsorber 1 is provided with the insulation material 3 covered in the electrodes 2 and 2 for adsorption, and the electrodes 2 and 2 for adsorption, impresses predetermined direct current voltage between the electrodes 2 and 2 for adsorption, and the semiconductor substrate 4, produces electrostatic force among both, and adsorbs and holds the semiconductor substrate 4 to the semiconductor substrate mounting surface 5.

[0003] Since the semiconductor substrate 4 is heated by plasma, in order to maintain at a suitable temperature, cooling is needed in many cases. Since the usual plasma treatment is performed under the low-pressure power of about several pascals, its efficiency of heat transfer between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 is low, and its cooling efficiency of the semiconductor substrate 4 is bad. Then, adsorbing the semiconductor substrate 4 in the semiconductor substrate mounting surface 5, among both, heat transfer gas, such as helium (helium) with large thermal conductivity, is passed from the heat transfer gas feed pipe 6 formed in the adsorber 1, thermal conductance between both is enlarged, and heat transfer is promoted. Although not illustrated here, rugged form is formed in the surface of the semiconductor substrate mounting surface 5, and it is devised so that the pressure of the gas for heat transfer may become uniform on the outskirts of a center and the outskirts of the semiconductor substrate 4.

[0004] The refrigerant passage 7 is formed in the inside of the adsorber 1, a refrigerant is supplied to the refrigerant passage 7 from the refrigerant supply port 8, and it is discharged from the refrigerant outlet 9. The heat is transferred to the semiconductor substrate mounting surface 5 from the semiconductor substrate 4 is discharged out of equipment with this refrigerant. It is for the covering 10 protecting the adsorber 1 from plasma.

[0005] There are an acyclic type whose polarity of the voltage which the electrode 2 for adsorption impresses by one is one, and a bipolar type whose polarity of the voltage which the electrode 2 for adsorption impresses or more by two is two in an electrostatic adsorber. The conventional example shown in drawing 7 is the adsorber 1 of a bipolar type with which the electrode 2 for adsorption separated to two by the side of a periphery and inner circumference. In order to take a treating chamber wall and conduction via plasma in the case of an acyclic type, unless it generates plasma on the semiconductor substrate 4, adsorption power does not arise. In order that a bipolar type may impress the voltage of plus and minus to each of the electrode which adjoins mutually by DC power supply 11 on the other hand to the two or more electrodes 2 for adsorption laid underground into the semiconductor substrate attachment component. In the adjoining inter-electrode one for adsorption, the line of electric force of an opposite direction arises via the semiconductor substrate 4, and even if it does not generate plasma, there is an advantage that the semiconductor substrate 4 can be adsorbed. Therefore, a bipolar type is becoming in use instead of an acyclic type in recent years.

[0006] As stated above, electrostatic adsorbers are a plasma device, especially a plasma etching device, and in order to cool the semiconductor substrate 4 heated by plasma etc., they are used widely. On the other hand, in a certain kind of plasma CVD, it is required to process the semiconductor substrate 4 at a temperature higher than a room temperature, and the semiconductor substrate 4 is beforehand heated before processing. In such equipment, the electrostatic adsorber with a heating machine style is used. For example, JP,S59-124140,A has disclosed the electrostatic adsorber which contained the heater in the attachment component. In the process of heating and processing a semiconductor substrate to an elevated temperature, this tries to attain quality improvement of the improvement in a throughput, and processing by carrying out preheating of the semiconductor substrate, before generating plasma.

[0007] JP,H9-17849,A has disclosed the electrostatic adsorber which sandwiched the intervening layer which consists of the combination or the firing object of fiber made from heat-resistant materials between the attachment component (product made from ceramics) which built in the heater, and the cooling system (metal) which contains a refrigerant passage. An object of this invention since the problem of destruction by generating of heat stress arising, or operating upper limit temperature being restricted to 150 °C or less had arisen when joining a cooling system to an attachment component via metal, such as brazing and indium, is to solve these. In order to attain this purpose, it tries to perform heat transfer between an attachment component and a cooling system by fixing an attachment component and a cooling system mechanically on both sides of an intervening layer, preventing generating of heat stress. The technology of adjusting the heat transfer amount between an attachment component and a cooling system is also indicated by adjusting the crimping force between an attachment component and a cooling system.

[0008]

[Problem to be solved by the invention]In the conventional technology explained above, especially the electrostatic adsorber having a heater, it is necessary to carry out temperature up of the semiconductor substrate to a desired temperature for a short time. However, there is a problem that the rise in heat of a semiconductor substrate prompt for the calorific capacity which the electrostatic adsorber itself has is barred. When temperature of an electrostatic adsorber is made high too much in the case of heating with a heater, the wall temperature of the refrigerant passage of a cooling member goes up, and there is a problem of exceeding the application-limits temperature of a refrigerant. In the case of heating, there is a method of discharging the refrigerant inside a refrigerant passage. However, in this method, when shifting to the plasma treatment of a semiconductor substrate after preheating, a refrigerant must be flowed into a hot channel and the problem that the temperature of a refrigerant passage wall surface will exceed the application-limits temperature of a refrigerant still remains. In JP,H9-17849,A, the method of changing the heat transfer quantity between an attachment component and a cooling system is indicated by adjusting the crimping force between an attachment component and a cooling system. However, since it is necessary to carry out an operation stop and to adjust equipment in this method, it is difficult to change the heat transfer amount between a semiconductor substrate attachment component and a cooling system in the midst of carrying out plasma treatment of the semiconductor substrate. Therefore, it cannot become a solving means of the above-mentioned problem.

[0009]The purpose of this invention solves the above-mentioned problem, can perform properly heat transfer between an attachment component and a cooling system, and provides the semiconductor processor which realized the high-precision semiconductor process, and a disposal method.

[0010]

[Means for solving problem]In the plasma treatment apparatus provided with the adsorber with the attachment component which built the heating element in the inside, and the cooling member which pours a refrigerant inside to achieve the above objects in this invention, The heat transfer gas room which encloses heat transfer gas is provided between said attachment component and said cooling member, by controlling said pressure of the heat transfer gas interior of a room, the thermal conductance between an attachment component and a cooling member is changed, and a heat transfer amount is controlled.

[0011]Even if equipment is working, since it is easy, changing the pressure of the heat transfer gas interior of a room can control the heat transfer amount between an attachment component and a cooling member during processing of a semiconductor substrate. The heat of the attachment component which lowered the pressure of the heat transfer gas interior of a room taking advantage of this advantage when carrying out preheating of the semiconductor substrate, and was heated with the heating element is made hard to tell a cooling member.

[0012]On the other hand, when performing plasma treatment to a semiconductor substrate, the pressure of heat transfer gas is raised to the heat transfer gas interior of a room, and heat transfer from an attachment component to a cooling system is made good. Since what is necessary is just to raise the temperature of only an attachment component and a semiconductor substrate in the case of heating with a heater if it does in this way, prompt preheating is possible.

[0013]Even if it sets up cooking temperature highly, the problem that the wall temperature of the refrigerant passage in a cooling member will exceed the application-limits temperature of a refrigerant is also lost. When generating plasma and processing a semiconductor substrate, the heat told to the attachment component from the semiconductor substrate can be efficiently told to a cooling member via the heat transfer gas of the heat transfer gas interior of a room, and can be further discharged out of equipment through a refrigerant.

[0014]

[Mode for carrying out the invention]Hereafter, the embodiment of this invention is described in detail according to figures.

[0015]Drawing 1 is the owner magnetic field microwave plasma CVD system which applied the 1st embodiment of this invention. The quartz cap 13 is installed on the side attachment wall 12, the adsorber 1 is formed in the processing chamber 14 which constitutes by this, and it processes by adsorbing the

semiconductor substrate 4 on it. The raw gas 16 serves as the plasma 21 by the interaction of the microwave 18 which was introduced in the processing chamber 14 through the nozzle 15, and was introduced through the wave guide tube 17, and the magnetic field induced by the coil 20 attached to the surroundings of the discharge tube 19. It processes by exposing the semiconductor substrate 4 to this plasma 21 (here membrane formation processing). The raw gas 16 and a resultant are discharged from the exhaust port 22.

[0016]Drawing 2 is a sectional side elevation of the adsorber 1 of the 1st embodiment, and expands and shows a situation when the semiconductor substrate 4 is adsorbed. The adsorber 1 is roughly divided and comprises the attachment component 23, the cooling member 24, and the covering 10. A film of the insulation material 3 is formed in the upper surface of the attachment component 23, the electrode 2 for adsorption is installed on it, and the semiconductor substrate mounting surface 5 is formed by forming a film of the insulation material 3 again on it. The semiconductor substrate 4 sticks to the semiconductor substrate mounting surface 5 by carrying out the seal of approval of the voltage of two poles of minus to the electrode 2 for adsorption at electrode 2' for plus and adsorption. The adsorber 1 whole was penetrated up and down, the pusher pin 28 is formed, and it serves to deliver the semiconductor substrate 4 carried in a processing chamber using a transportation arm (not shown here) to the adsorber 1. The attachment component 23 can be heated to temperature of a request of the attachment component 23 by building in the heating element 25 and controlling the calorific value. In order to supply heat transfer gas, such as helium, between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, the heat transfer gas feed pipe 6 is formed in an inside of the attachment component 23. By controlling a pressure of this heat transfer gas, thermal conductance between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 is adjusted.

[0017]The refrigerant passage 7 is formed in the inside of the cooling member 24, a refrigerant is supplied from the refrigerant supply port 8 with the outside connected cooling system, it passes along the refrigerant passage 7, and the cooling member 24 is cooled by discharging from the refrigerant outlet 9. The heat which the semiconductor substrate 4 receives during plasma treatment is missed to the refrigerant which flows through the inside of the refrigerant passage 7 via this cooling member 24.

[0018]Between the attachment component 23 and said cooling member 24, the heat transfer gas room 26 which encloses gas is formed. In the embodiment shown in drawing 2, the heat transfer gas room 26 is formed between the attachment components 23 by providing a dent in the upper surface of the cooling member 24. The peripheral part of the heat transfer gas room 26 and the outside of pusher pin 28 through hole are joined by welding, and the attachment component 23 and the cooling member 24 serve as a closed space. In order to join the attachment component 23 and the cooling member 24 by welding, these both form with metal. By enclosing gases, such as gaseous helium, through the pipe 27 in this heat transfer gas room 26, or discharging, the pressure in the heat transfer gas room 26 is controlled, and it is considered as the structure of adjusting the thermal conductance between the attachment component 23 and the cooling member 24 by this.

[0019]The enlarged drawing of the side section of the adsorber 1 in which the 2nd embodiment of this invention is shown is shown in drawing 3.

[0020]In this embodiment, the attachment component 23 and the cooling member 24 are mechanically fixed with the bolt 30. The slot on the circle configuration is formed in the cooling member 24 at the peripheral part of the heat transfer gas room 26, and the outside of pusher pin 28 through hole, and the seal is carried out so that the gas in the heat transfer gas room 26 may not leak with O ring 31. The differences between Embodiment 1 and this example are the following points. That is, when heating the semiconductor substrate 4 with the heating element 25, the amount of dimensional changes by thermal expansion differs between the attachment component 23 and the cooling member 24 from the difference between temperature and construction material. However, since it is only fixing mechanically with the bolt 30, the attachment component 23 and the cooling member 24 of a possibility of stress not being produced in both interface but destroying to it are low. As stated previously, since the attachment component 23 and the cooling member 24 omit junction by welding, they do not need to use a material of the same kind,

and can choose it freely. For example, the attachment component 23 heated by the elevated temperature can be manufactured with heat-resistant materials, such as ceramics, and can manufacture the cooling member 24 with a metallic material with high thermal conductivity.

[0021]An enlarged drawing of a side section of the adsorber 1 in which the 3rd embodiment of this invention is shown is shown in drawing 4.

[0022]In this embodiment, the thermometer 32 for measuring temperature of the semiconductor substrate 4 is provided. Temperature of the semiconductor substrate 4 or the attachment component 23 after carrying in the semiconductor substrate 4 to 14 in a processing chamber until it takes out can be measured, and a measuring result can be told to a controller (not shown) currently installed outside.

[0023]A more nearly quality semiconductor process can be performed to the semiconductor substrate 4 by managing temperature of the semiconductor substrate 4 in early stages of semiconductor process processes, such as membrane formation or etching, and temperature of the semiconductor substrate 4 in a semiconductor process process by feedback control here.

[0024]In order to manage initial temperature of processes, such as membrane formation or etching, temperature control under preheating of the attachment component 23 by the heating element 25 is important.

[0025]For example, if a rise in heat of the semiconductor substrate 4 is late during preheating of the attachment component 23 by the heating element 25. By raising a pressure of gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, thermal conductance between the semiconductor substrate mounting surface 5 and the semiconductor substrate 4 which temperature went up becomes large, and a rise in heat of the semiconductor substrate 4 can be made quick. By raising calorific value of the heating element 25, a rise in heat of the semiconductor substrate mounting surface 5 can be made quick, and a rise in heat can be made quick for the semiconductor substrate 4.

[0026]On the contrary, if the rise in heat of the semiconductor substrate 4 is quick during the preheating of the attachment component 23 by the heating element 25, the rise in heat of the semiconductor substrate 4 can be made late by making calorific value of the heating element 25 small. By lowering the pressure of the gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, thermal conductance between the semiconductor substrate mounting surface 5 and the semiconductor substrate 4 which temperature went up can be made small, and the rise in heat of the semiconductor substrate 4 can be made late. By raising the pressure in the heat transfer gas room 26, thermal conductance between the attachment component 23 and the cooling member 24 can be enlarged, the rise in heat of the attachment component 23 can be made late, and the rise in heat of the semiconductor substrate 4 can be made late. The rise in heat of the semiconductor substrate 4 can be made late by control of lowering the temperature of the refrigerant which flows into cooling member 24 inside which raises the flow of the refrigerant which flows into the inside of the cooling member 24.

[0027]When the temperature of the semiconductor substrate 4 which the temperature of the semiconductor substrate 4 overshoot during the preheating of the attachment component 23 by the heating element 25, and became high needs to be lowered, By setting calorific value of the heating element 25 to 0 small, and raising the pressure in the heat transfer gas room 26, thermal conductance between the attachment component 23 and the cooling member 24 can be enlarged, the temperature of the attachment component 23 can be lowered, and the temperature of the semiconductor substrate 4 can be lowered. The temperature of the semiconductor substrate 4 can be lowered by control of lowering the temperature of the refrigerant which flows into cooling member 24 inside which raises the flow of the refrigerant which flows into the inside of the cooling member 24.

[0028]On the other hand, if the temperature of the semiconductor substrate 4 is low in processes, such as membrane formation or etching, by lowering the pressure of the gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, the thermal conductance between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 falls, and temperature of the semiconductor substrate 4 is made high — things can be carried out. By lowering the pressure of heat

transfer gas room 26 insides, the thermal conductance between the attachment component 23 and the cooling member 24 can be lowered, temperature of the attachment component 23 can be made high, and temperature of the semiconductor substrate 4 can be made high. by lowering the flow of the refrigerant which flows into the inside of the cooling member 24, or raising the temperature of the refrigerant which flows into the refrigerant passage 7, temperature of the cooling member 24 is made high and, as a result, temperature of the semiconductor substrate 4 is made high — things can be carried out. Temperature of the semiconductor substrate 4 can be made high also by making the heating element 25 generate heat. [0029] On the contrary, if the temperature of the semiconductor substrate 4 is high in semiconductor manufacturing processes, such as membrane formation or etching, by raising the pressure of the gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, the thermal conductance between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 is raised, and temperature of the semiconductor substrate 4 is made low — things can be carried out, by raising the pressure of heat transfer gas room 26 insides, the thermal conductance between the attachment component 23 and the cooling member 24 is raised, temperature of the attachment component 23 is made low, and temperature of the semiconductor substrate 4 is made low — things can be carried out, by raising the flow of the refrigerant which flows into the inside of the cooling member 24, or lowering the temperature of the refrigerant which flows into the refrigerant passage 7, temperature of the cooling member 24 is made low and, as a result, temperature of the semiconductor substrate 4 is made low — things can be carried out.

[0030] The enlarged drawing of the side section of the adsorber 1 in which the 4th embodiment of this invention is shown is shown in drawing 5.

[0031] In this embodiment, distance of the upper wall of the heat transfer gas room 26 and low wall in the central part is made smaller than an outer peripheral part. What the attachment component 23 constitutes among the walls of the heat transfer gas room 26 shall be shown, and, as for the upper wall of the heat transfer gas room 26, the low wall of the heat transfer gas room 26 shall show what the cooling member 24 constitutes among the walls of the heat transfer gas room 26. The differences between Embodiments 1-3 and this example are the following points. That is, when performing plasma treatment to the semiconductor substrate 4, the input calorie from the plasma 21 to the semiconductor substrate 4 may become large in the central part owing to the unevenness of the plasma 21, etc. In that case, when the thermal conductance in the heat transfer gas room 26 is uniform, in the central part, the temperature of the semiconductor substrate 4 becomes high, and the quality of the plasma treatment of the semiconductor substrate 4 worsens. However, thermal conductance in the central part can be enlarged by making distance of the upper wall of the heat transfer gas room 26 and low wall in the central part smaller than an outer peripheral part. Thereby, the rise in heat in the central part of the semiconductor substrate 4 is suppressed, and field internal temperature degree homogeneity improves.

[0032] Although distance of the upper wall of the heat transfer gas room 26 and low wall in the central part was made smaller than an outer peripheral part in this example, it does not limit to it. For example, if the input calorie to the semiconductor substrate 4 is small and becomes large by an outer peripheral part in the central part, thermal conductance in an outer peripheral part can be enlarged by making distance of the upper wall of the heat transfer gas room 26 and low wall in an outer peripheral part smaller than the central part. Thereby, the rise in heat in the outer peripheral part of the semiconductor substrate 4 is suppressed, and field internal temperature degree homogeneity improves.

[0033] Next, the procedure of performing membrane formation processing by plasma CVD to the semiconductor substrate 4 using the semiconductor processor of the 1-4th embodiments is explained. According to this procedure, a main operation and effect of this invention are explained to reference for drawing 6. Drawing 6 is a figure showing an example of the temporal change of the calorific value  $Q_1$  of the heating element 25, the input calorie  $Q_2$  from the plasma 21 to the semiconductor substrate 4, the pressure  $P_1$  in the heat transfer gas room 26, the temperature  $T_1$  of the semiconductor substrate mounting surface 5, and the temperature  $T_2$  of the semiconductor substrate 4. The horizontal axis of each graph expresses time, and if it is in the same position by a horizontal axis, it is shown that it is the same

time. The number with a parenthesis under a time-axis corresponds with the number of the operation explained below.

[0034](1) Make the heating element 25 generate heat at the time  $t_0$ . Thereby, although the attachment component 23 is heated, most thermal conductance which lets the heat transfer gas room 26 pass is set to 0 by a pressure in the heat transfer gas room 26 being about several same pascals as the processing chamber 14. Thereby, heating of the attachment component 23 by the heating element 25 hardly influences the refrigerant passage 7. That is, wall surface temperature of the refrigerant passage 7 hardly rises. Although Q1 is set constant by drawing 6 here in a time zone of  $t_0-t_1$  except the time of starting in the time  $t_0$ , it does not necessarily need to be fixed and Q1 may be changed between  $t_0-t_1$ .

[0035](2) Carry in the semiconductor substrate 4 to the processing chamber 14, and install in the semiconductor substrate mounting surface 5. Supply electric power in the electrodes 2 and 2 for adsorption, the semiconductor substrate 4 is made to stick to the semiconductor substrate mounting surface 5, and heat transfer gas, such as helium, is made to flow between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 at this time. By that cause, raise thermal conductance between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, heat transfer between both is made to perform good, and preheating of the semiconductor substrate 4 is performed. Although Q1 is set constant by drawing 6 here in a time zone of  $t_1-t_2$  in  $t_2$  bring down and excluding the time, it does not necessarily need to be fixed and Q1 may be changed between  $t_1-t_2$ .

[0036](3) Flow and hold heat transfer gas, such as helium, in the heat transfer gas room 26.

[0037](4) Stop generation of heat of the heating element 25 of attachment component 23 inside, and introduce raw gas in the processing chamber 14, generate the plasma 21, and make a film deposit on the semiconductor substrate 4. Heat transfer gas, such as helium, was flowed and held in the heat transfer gas room 26 in operation of the above (3). Thermal conductance between the attachment component 23 and the cooling member 24 which let the heat transfer gas room 26 pass is raised by this, heat transfer between both is performed good, by cooling the cooling member 24, temperature of the semiconductor substrate mounting surface 5 can be lowered, and T2 can be controlled. A solid line curved part of a graph of the temperature T1 of the semiconductor substrate mounting surface 5 of  $t_2-t_3$  and the temperature T2 of the semiconductor substrate 4 shows this example, and a dashed line curved part shows plasma treatment currently performed conventionally. Although T1 and T2 in early stages of plasma treatment are low and a temperature change under plasma treatment is large in a Prior art, a temperature change under plasma treatment can be small suppressed by enforcement of this invention.

[0038] Although P1 is set constant by drawing 6 here in a time zone of  $t_2-t_3$  except the time of starting in  $t_2$ , it does not necessarily need to be fixed and P1 may be changed between  $t_2-t_3$ .

[0039](5) Stop supply of raw gas, extinguish the plasma 21, and end plasma treatment.

[0040](6) Take out the semiconductor substrate 4 which plasma treatment ended outside the processing chamber 14. Heat transfer gas shall be discharged from the heat transfer gas room 26, and a pressure shall be about several same pascals as the processing chamber 14. Set to 0 by this most thermal conductance between the attachment component 23 and the cooling member 24 which let the heat transfer gas room 26 pass, the heating element 25 is made to generate heat to (7) time  $t_0'$  which sets most heat transfer amounts between both to 0, and the attachment component 23 is heated. By processing to  $t_0-t_3$ , since T1 in  $t_0'$  is higher than T1 in  $t_0$ , it heats by making Q1 in  $t_0' - t_1'$  smaller than the time of  $t_0-t_1$ . Although Q1 is set constant by drawing 6 here in a time zone of  $t_0'$  except the time of starting in  $t_0' - t_1'$ , it does not necessarily need to be fixed and Q1 may be changed between  $t_0' - t_1'$ . T1 in  $t_0'$  is high enough, and it is not necessary to perform heating by the heating element 25 without the necessity of heating the processed object mounting surface 5 in  $t_0' - t_1'$ .

[0041] Most thermal conductance which lets the heat transfer gas room 26 pass by operation of the above (6) is 0. Thereby, heating of the attachment component 23 by the heating element 25 hardly influences the refrigerant passage 7. That is, the wall surface temperature of the refrigerant passage 7 hardly rises.

[0042](8) Carry in the new semiconductor substrate 4 to the processing chamber 14, and install the semiconductor substrate 4 in the semiconductor substrate mounting surface 5. Supply electric power in

the electrodes 2 and 2 for adsorption, the semiconductor substrate 4 is made to stick to the semiconductor substrate mounting surface 5, and heat transfer gas, such as helium, is made to flow between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 at this time. By that cause, raise the thermal conductance between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, the heat transfer between both is made to perform good, and preheating of the semiconductor substrate 4 is performed. Although Q1 is set constant by drawing 6 here in the time zone of t1' bring down and excluding the time - t2' in t2', it does not necessarily need to be fixed and Q1 may be changed between t1' - t2'. T1 in t0' is high enough, and it is not necessary to perform heating by the heating element 25 without the necessity of heating the processed object mounting surface 5 in t0' - t1'. In t2 and t2', it is equal here in the temperature T2 of the semiconductor substrate 4, that is, it is important in a semiconductor process process at each time to make equal T2 at the time of a processing start.

[0043](9) Flow and hold heat transfer gas, such as helium, in the heat transfer gas room 26.

[0044](10) While stopping generation of heat of the heating element 25 of attachment component 23 inside, introduce raw gas in the processing chamber 14, generate the plasma 21, and make a film deposit on the semiconductor substrate 4. Although heat transfer gas, such as helium, was flowed and held in the heat transfer gas room 26 in operation of the above (9), Thermal conductance between the attachment component 23 and the cooling member 24 which let the heat transfer gas room 26 pass by this is raised, heat transfer between both is performed good, by cooling the cooling member 24, control of temperature of the semiconductor substrate mounting surface 5 is enabled, and T2 can be controlled.

[0045]Although P1 is set constant by drawing 6 here in a time zone of t2' except the time of starting in t2' - t3', it does not necessarily need to be fixed and P1 may be changed between t2' - t3'.

[0046](11) Stop supply of raw gas, extinguish the plasma 21, and end plasma treatment.

[0047](12) Take out the semiconductor substrate 4 which plasma treatment ended outside the processing chamber 14. Heat transfer gas shall be discharged from the heat transfer gas room 26, and a pressure shall be about several same pascals as the processing chamber 14, thereby -- heat transfer gas -- a room -- 26 -- having let it pass -- an attachment component -- 23 -- a cooling member -- 24 -- between -- thermal conductance -- almost -- zero -- carrying out -- both -- between -- a heat transfer amount -- almost -- zero -- carrying out -- the above -- having explained -- a procedure -- ( -- seven -- ) - ( -- 12 -- ) -- next -- repeating -- things -- a semiconductor substrate -- four -- continuing -- it can process . Gas pressure made to flow between the calorific value Q1 of the heating element 25, the pressure P1 in the heat transfer gas room 26, the semiconductor substrate 4, and the semiconductor substrate mounting surface 5 when processing the semiconductor substrate 4 continuously, As for a flow and temperature of a refrigerant which are made to flow into a cooling member, it is not necessarily optimal to use the same thing in a treatment process at each time. It is important to make T2 in to make small change of T2 in t2-t3 and t2' - t3', and t2-t3 reproduce by a treatment process at each time at this example, The calorific value Q1 of the heating element 25 in t0-t3 or t0' - t3', the pressure P1 of the heat transfer gas room 26, and the temperature T1 of the attachment component 23 upper surface are not restricted to what was shown in drawing 6.

[0048]Temperature of the semiconductor substrate [ in / on a semiconductor process method shown in this example, and / early stages of semiconductor process processes, such as membrane formation or etching ] 4, And a more nearly quality semiconductor process can be performed to the semiconductor substrate 4 by managing temperature of the semiconductor substrate 4 in a semiconductor process process by feedback control.

[0049]In order to manage temperature in early stages of semiconductor process processes, such as membrane formation or etching, it is important for t1-t2 or t1' - t2' to manage T2.

[0050]For example, if a rise of T2 is slow to t1-t2 or t1' - t2', by raising a pressure of gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, thermal conductance between the semiconductor substrate mounting surface 5 and the semiconductor substrate 4 which raised temperature can be enlarged, and a rise of T2 can be made quick. By raising Q1, a rise in heat of the

semiconductor substrate mounting surface 5 can be made quick, and a rise in heat can be made quick for the semiconductor substrate 4.

[0051] Conversely, if a rise of T2 is quick to  $t1-t2$  or  $t1' - t2'$ , a rise of T2 can be made late by making Q1 small. By lowering a pressure of gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, thermal conductance between the semiconductor substrate mounting surface 5 and the semiconductor substrate 4 which temperature went up can be made small, and a rise of T2 can be made late. By raising P1, thermal conductance between the attachment component 23 and the cooling member 24 can be enlarged, a rise in heat of the attachment component 23 can be made late, and a rise of T2 can be made late. A rise of T2 can be made late by control of lowering temperature of a refrigerant which flows into cooling member 24 inside which raises a flow of a refrigerant which flows into an inside of the cooling member 24.

[0052] When T2 which T2 overshoot to  $t1-t2$  or  $t1' - t2'$ , and became high needs to be lowered, By setting Q1 to 0 small and raising P1, thermal conductance between the attachment component 23 and the cooling member 24 can be enlarged, T1 can be lowered, and, as a result, T2 can be lowered. T2 can be lowered by control of lowering temperature of a refrigerant which flows into cooling member 24 inside which raises a flow of a refrigerant which flows into an inside of the cooling member 24.

[0053] on the other hand --  $t2-t3$ , or  $t2$  -- if T2 is low to ' $t3$ ', by lowering a pressure of gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, thermal conductance between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 will fall, and T2 will be made high -- things can be carried out. By lowering P1, thermal conductance between the attachment component 23 and the cooling member 24 can be lowered, T1 can be made high, and, as a result, T2 can be made high. by lowering a flow of a refrigerant which flows into an inside of the cooling member 24, or raising temperature of a refrigerant which flows into the refrigerant passage 7, temperature of the cooling member 24 is made high and, as a result, T2 is made high -- things can be carried out. T2 can be made high also by making the heating element 25 generate heat.

[0054]  $t2-t3$ , or  $t2$  -- if T2 is high to ' $t3$ ', by raising the pressure of the gas between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5, the thermal conductance between the semiconductor substrate 4 and the semiconductor substrate mounting surface 5 will go up, and T2 will be made low -- things can be carried out. [ conversely, ] by raising P1, the thermal conductance between the attachment component 23 and the cooling member 24 is raised, T1 is made low, and, as a result, T2 is made low -- things can be carried out. by raising the flow of the refrigerant which flows into the inside of the cooling member 24, or lowering the temperature of the refrigerant which flows into the refrigerant passage 7, temperature of the cooling member 24 is made low and, as a result, T2 is made low -- things can be carried out.

[0055] Although plasma CVD was made into the example and the disposal method was explained here, it cannot be overemphasized that this is not restricted to plasma CVD and it can be used, for example for processing by other means of semiconductor manufactures of plasma etching, the heat CVD, etc.

[0056]

[Effect of the Invention] As explained above, according to this invention, in the semiconductor processor using an adsorber, the outstanding semiconductor process method which can provide the semiconductor processor [ preheating is possible to an elevated temperature in a semiconductor substrate, and ] which can perform temperature control with a sufficient response to a semiconductor substrate, and is performed to a semiconductor substrate can be provided.

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is a sectional side elevation of the semiconductor processor in which the 1st embodiment of this invention is shown.

[Drawing 2] It is an enlarged drawing of the side section of the adsorber currently used for the semiconductor processor in which the 1st embodiment of this invention is shown.

[Drawing 3] It is an enlarged drawing of the side section of the adsorber currently used for the semiconductor processor in which the 2nd embodiment of this invention is shown.

[Drawing 4] It is an enlarged drawing of the side section of the adsorber currently used for the semiconductor processor in which the 3rd embodiment of this invention is shown.

[Drawing 5] It is an enlarged drawing of the side section of the adsorber currently used for the semiconductor processor in which the 4th embodiment of this invention is shown.

[Drawing 6] It is a sequence diagram showing the semiconductor process method which shows the 5th embodiment of this invention.

[Drawing 7] It is a sectional side elevation showing the conventional example of an adsorber.

[Explanations of letters or numerals]

1 [ -- A semiconductor substrate, 5 / -- Semiconductor substrate mounting surface, ] -- An adsorber, 2 -- The electrode for adsorption, 3 -- An insulation material, 4 6 [ -- Fluid outlet, ] -- A heat transfer gas feed pipe, 7 -- A refrigerant passage, 8 -- A fluid supply mouth, 9 10 [ -- A quartz cap, 14 / -- Processing chamber, ] -- Covering, 11 -- DC power supply, 12 -- A side attachment wall, 13 15 [ -- Microwave, ] -- A nozzle, 16 -- Raw gas, 17 -- A wave guide tube, 18 19 [ -- An exhaust port, 23 / -- An attachment component, 24 / -- A cooling member, 25 / -- A heating element, 26 / -- A heat transfer gas room, 7 / -- A pipe, 28 / -- A pusher pin, 29 / -- A pusher pin introducing pipe, 30 / -- A bolt, 31 / -- An O ring, 32 / -- Thermometer. ] -- A discharge tube, 20 -- A coil, 21 -- Plasma, 22

[Translation done.]

\* NOTICES \*

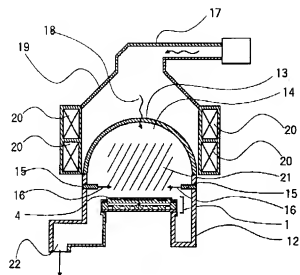
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## DRAWINGS

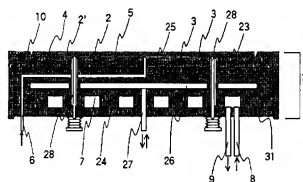
[Drawing 1]

図1



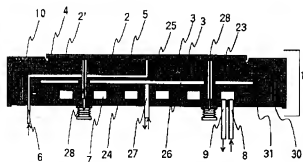
[Drawing 2]

図2



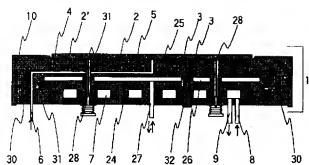
[Drawing 3]

図3



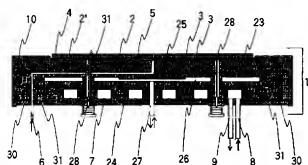
[Drawing 4]

図4



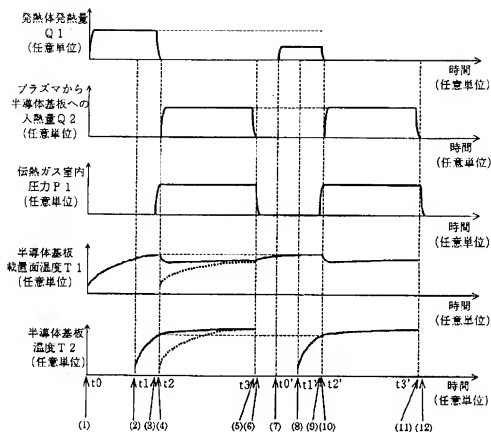
[Drawing 5]

図5



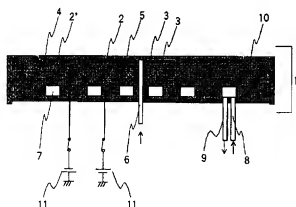
[Drawing 6]

図 6



[Drawing 7]

図7



[Translation done.]

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号  
特開2001-110885  
(P2001-110885A)

(43) 公開日 平成13年4月20日 (2001.4.20)

(51) Int.Cl. <sup>7</sup>	識別記号	F I	チーコード <sup>7</sup> (参考)		
H 0 1 L	21/68	H 0 1 L	21/68	R	5 F 0 0 4
	21/205		21/205		5 F 0 3 1
	21/3065		21/302	B	5 F 0 4 5

審査請求 未請求 請求項の数10 O L (全 10 頁)

(21) 出願番号 特願平11-291799

(22) 出願日 平成11年10月14日 (1999. 10. 14)

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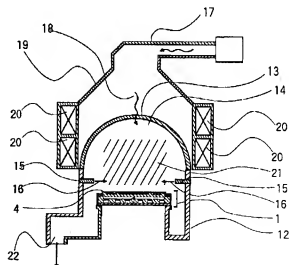
(54) 【発明の名称】 半導体処理装置および半導体処理方法

(57) 【要約】

【課題】 吸着装置を用いた半導体処理装置において、半導体基板を高温に予備加熱することが可能であり、温度制御の応答性の良い吸着装置を備え、半導体基板に優れた処理を行うことを可能とする半導体処理装置を提供する。

【解決手段】 半導体基板載置面5に半導体基板4を保持可能な吸着装置1を備えた半導体処理装置において、半導体基板載置面5に半導体基板4を保持する保持部材23と冷却部材24との間にガスを封入する伝熱ガス室26を設ける。

図1



【特許請求の範囲】

【請求項1】半導体基板を保持するための保持部材と、冷却を行うための冷却部材を備えた吸着装置において、前記保持部材と前記冷却部材との間にガスを封入、排出させる伝熱ガス室を設けたことを特徴とする吸着装置を備えた半導体処理装置。

【請求項2】前記保持部材の内部に吸着用電極を備え、前記半導体基板と前記保持部材との間にガスを導入する手段を備えたことを特徴とする請求項1に記載の半導体処理装置。

【請求項3】前記冷却部材の内部に冷媒を流入することを特徴とする請求項1もしくは2に記載の半導体処理装置。

【請求項4】前記保持部材の内部に発熱体を備えたことを特徴とする請求項1～3のいずれかに記載の半導体処理装置。

【請求項5】前記半導体基板と前記保持部材と、前記冷却部材と前記伝熱ガス室が、上から前記処理体、前記保持部材、前記伝熱ガス室、前記冷却部材の順に配置されたことを特徴とする請求項1～4のいずれかに記載の半導体処理装置。

【請求項6】前記半導体基板の温度と、前記保持部材の温度と、前記冷却部材に流入する前記冷媒の温度と、前記伝熱ガス室内の圧力のうち少なくとも一つを測定する手段を有し、その測定結果を用いて、前記発熱体の発熱量と、前記半導体基板と前記保持部材との間に供給された気体の圧力と、前記冷却部材内の前記冷媒流路内の前記冷媒の温度と、前記冷却部材内の前記冷媒流路内の前記冷媒の流量と、前記伝熱ガス室の圧力のうち、少なくとも一つをフィードバック制御する請求項1～5のいずれかに記載の半導体処理装置。

【請求項7】処理室内に半導体基板を搬入し発熱体を内蔵した保持部材上に半導体基板を吸着する工程と、半導体基板と保持部材との間に気体を供給して圧力を上昇させる工程と、保持部材内部の発熱体を発熱させて半導体基板を加熱する工程と、処理室内にプラズマを発生させるとともに保持部材と冷却部材との間に気体を供給して圧力を上昇させる工程と、プラズマを消滅させ成膜を終了させる工程と、半導体基板を処理室から搬出する工程を含むことを特徴とする半導体処理方法。

【請求項8】処理室内に半導体基板を搬入し発熱体を内蔵した保持部材上に半導体基板を吸着する工程と、半導体基板と保持部材との間に気体を供給して圧力を上昇させる工程と、保持部材内部の発熱体を発熱させて半導体基板を加熱する工程と、処理室内に処理ガスを導入させるとともに保持部材と冷媒流路を内蔵した冷却部材との間に気体を供給して圧力を上昇させる工程と、処理ガスの導入を止め、処理を終了させる工程と、半導体基板を処理室から搬出する工程を含むことを特徴とする半導体処理方法。

【請求項9】請求項7または請求項8に記載の半導体処理方法において、

前記各工程を1サイクルとして連続して繰り返すことにより複数枚の基板を処理する時に、前記保持部材内部の発熱体を発熱させて半導体基板を加熱する工程の発熱熱量を、各処理サイクル毎に異ならせることを特徴とする半導体処理方法。

【請求項10】請求項7または請求項8に記載の半導体処理方法において、前記各工程を1サイクルとして連続して繰り返すことにより複数枚の基板を処理する時に、前記保持部材と冷媒流路を内蔵した冷却部材との間に気体を供給して圧力を上昇させる工程において、各処理サイクルごとに異なる圧力を与えることを特徴とする半導体処理方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は半導体処理装置に係り、特に、半導体ウェハなど半導体基板の温度管理を必要とする半導体処理プロセスにおいて、処理過程において、半導体基板から熱を除去したり、もしくは半導体基板を加熱したりする吸着装置を備えた半導体製造装置および処理方法に関する。

【0002】

【従来の技術】従来より半導体製造工程において、半導体ウェハなどの半導体基板を処理するために、反応性プラズマを利用したプラズマCVD (Chemical Vapor Deposition) 装置やプラズマエッチング装置等が使用されている。これらのプラズマ処理装置では、静電吸着装置が広く用いられている。以下、図7に従って静電吸着装置の説明を行う。吸着装置1は、吸着用電極2および2'と吸着用電極2、2'を被覆する絶縁材3とを備え、吸着用電極2、2'と半導体基板4との間に所定の直流電圧を印加して、両者間に静電気力を生じさせ、半導体基板4を半導体基板載置面5に吸着、保持するものである。

【0003】半導体基板4はプラズマによって加熱されるため、適切な温度に保つためには冷却が必要となることが多い。通常のプラズマ処理は数Pa程度の低圧下で行うので、半導体基板4と半導体基板載置面5との間の伝熱効率が低く、半導体基板4の冷却効率が悪い。そこで、半導体基板4を半導体基板載置面5に吸着しながら、両者間に熱伝導率が大きいヘリウム (He) などの伝熱ガスを吸着装置1内に形成された伝熱ガス供給管6から流し、両者間の熱コンダクタンスを大きくし、伝熱を促進している。なお、ここには図示しないが半導体基板載置面5の表面には凹凸状の形状が形成されており、半導体基板4の中心と周囲で伝熱用ガスの圧力が一樣になるよう工夫されている。

【0004】吸着装置1の内部には冷媒流路7が形成されており、冷媒供給口8から冷媒を冷媒流路7へ供給

し、冷媒排出口9から排出する。半導体基板4から半導体基板載置面5に伝えられた熱を、この冷媒で装置外に排出している。なお、カバー10は吸着装置1をブラズマから保護するためのものである。

【0005】静電吸着装置には、吸着用電極2が1つで印加する電圧の極性が1つの単極型と、吸着用電極2が2つ以上で印加する電圧の極性が2つの双極型とがある。図7に示す従来例は、吸着用電極2が外周側と内周側の2つに別れた双極型の吸着装置1である。単極型の場合、ブラズマを介して処理室壁と導通をとるため、半導体基板4上にブラズマを発生させない吸着力が生じない。一方、双極型は半導体基板保持部材中に埋設された2つ以上の吸着用電極2に対して、互いに隣接する電極のそれぞれにプラスとマイナスの電圧を直流電源11によって印加するため、隣接する吸着用電極間には半導体基板4を介して逆方向の電気力線が生じ、ブラズマを発生させなくても半導体基板4を吸着できるという利点がある。そのため、近年双極型が単極型に代わって主流になりつつある。

【0006】以上述べたように、静電吸着装置はブラズマ装置、特にブラズマエッチング装置で、ブラズマなどによって加熱される半導体基板4を冷却するために広く用いられている。一方、ある種のブラズマCVDなどでは半導体基板4を室温よりも高い温度で処理することが必要であり、処理前に半導体基板4を予め加熱する。このような装置においては、加熱機構を有した静電吸着装置が用いられている。例えば、特開昭59-124140号公報には、ヒータを保持部材中に内蔵した静電吸着装置が開示されている。これは、ブラズマを発生する前に半導体基板を予備加熱することにより、半導体基板を高温に加熱して処理するプロセスにおいてスループット向上、処理の高品質化を図ろうとするものである。

【0007】また、特開平9-17849号公報には、ヒータを内蔵した保持部材（セラミック製）と冷媒流路を内蔵する冷却装置（金保製）との間に耐熱材料製の繊維の結合体または発熱体からなる介在層を挟んだ静電吸着装置が開示されている。この発明は、保持部材と冷却装置をろう付けやインジウムなどの金属を介して接合する際に熱応力の発生による破壊が生じたり、使用上限温度が150℃以下に制限されるなどの問題が生じていたため、これらを解決することを目的としている。この目的を達成するため、保持部材と冷却装置とを介在層を挟んで機械的に固定することにより、熱応力の発生を防止しながら保持部材と冷却装置との間の伝熱を行おうとするものである。さらに、保持部材と冷却装置との間の圧着力を調整することによって、保持部材と冷却装置との間の伝熱量を調整する技術も開示している。

【0008】

【発明が解決しようとする課題】以上説明した従来技術、特にヒータを内蔵した静電吸着装置においては、短

時間に半導体基板を所望の温度に昇温することが必要となる。しかし、静電吸着装置自身が持つ熱容量のために速やかな半導体基板の温度上昇が妨げられるという問題がある。また、ヒータによる加熱の際に静電吸着装置の温度を高くしすぎると、冷却部材の冷媒流路の壁温が上がってしまい、冷媒の使用限界温度を超えてしまうという問題がある。加熱の際に冷媒流路内部の冷媒を排出するという方法がある。しかしこの方法では、予備加熱後に半導体基板のブラズマ処理に移る際に、高温の流路に冷媒を流入しなければならず、冷媒流路壁面の温度が冷媒の使用限界温度を超えてしまうという問題は依然として残る。また、特開平9-17849号公報では、保持部材と冷却装置との間の圧着力を調節することによって、保持部材と冷却装置との間の熱伝達率を変化させる方法を開示している。しかし、この方法では、装置を稼動停止して調整が必要があるため、半導体基板をブラズマ処理している最中に半導体基板保持部材と冷却装置との間の伝熱量を変化させることは困難である。従って、上記の問題点の解決手段とはなり得ない。

20 【0009】本発明の目的は、上記問題点を解決し保持部材と冷却装置間の熱伝達を適正に行え、精度の高い半導体処理を実現した半導体処理装置と、処理方法を提供するものである。

【0010】

【課題を解決するための手段】本発明では上記目的を達成するために、内部に発熱体を内蔵した保持部材と内部に冷媒を流す冷却部材を有した吸着装置を備えたブラズマ処理装置において、前記保持部材と前記冷却部材との間に伝熱ガスを封入する伝熱ガス室を設け、前記伝熱ガス室内の圧力を制御することによって保持部材と冷却部材との間の熱コンダクタンスを変化させ、伝熱量を制御する。

【0011】装置が稼動中であっても伝熱ガス室内の圧力を変化させることは容易であるため、半導体基板の処理中に保持部材と冷却部材の間の伝熱量を制御することができる。この利点を生かし、半導体基板を予備加熱する際には伝熱ガス室内の圧力を下げて、発熱体により加熱された保持部材の熱を冷却部材に伝えにくくする。

40 【0012】一方、半導体基板にブラズマ処理を施す時には、伝熱ガス室内に伝熱ガスの圧力を上げ、保持部材から冷却装置への伝熱を良好にする。このようにすれば、ヒータによる加熱の際には保持部材と半導体基板のみの温度を上げれば良いので、速やかな予備加熱が可能である。

【0013】また、加熱温度を高く設定しても、冷却部材内の冷媒流路の壁温が冷媒の使用限界温度を超えてしまうという問題もなくなる。さらに、ブラズマを発生させて半導体基板を処理する時には、半導体基板から保持部材に伝えられた熱を、伝熱ガス室内の伝熱ガスを介して効率的に冷却部材に伝えることかき、さらに冷媒を

通して装置外に排出できる。

【0014】

【発明の実施の形態】以下、本発明の実施例を図に従って詳しく説明する。

【0015】図1は本発明の第1の実施例を適用した有磁場マイクロ波プラズマCVD装置である。側壁12の上に石英蓋13を設置し、これにより構成する処理室14内に吸着装置1を設け、その上に半導体基板4を吸着して処理を行う。処理ガス16は、ノズル15を通して処理室14内に導入し、導波管17を通して導入したマイクロ波18と放電管19の周りに取り付けられたコイル20により誘起された磁場との相互作用によりプラズマ21となっている。半導体基板4をこのプラズマ21にさらすことによって処理（ここでは成膜処理）を行う。処理ガス16、及び反応生成物は排気口22から排出する。

【0016】図2は第1の実施例の吸着装置1の側断面図であり、半導体基板4を吸着した時の様子を拡大して示している。吸着装置1は大きく分けて保持部材23、冷却部材24とカバー10から構成されている。保持部材23の上面には絶縁材3の膜を形成し、その上に吸着用電極2を設置し、その上に再度絶縁材3の膜を形成することにより半導体基板載置面5を形成する。吸着用電極2にプラス、吸着用電極2'にマイナスの両極の電圧を印加することによって半導体基板4が半導体基板載置面5に吸着する。吸着装置1全体を上下に貫通してブッシュピン28を設けており、搬送アーム（ここには図示しない）を用いて処理室内に搬入した半導体基板4を吸着装置1へと受け渡す動きをする。保持部材23は発熱体25を内蔵し、その発熱量を制御することにより、保持部材23を所望の温度に加熱することができる。半導体基板4と半導体基板載置面5との間にヘリウムなどの伝熱ガスを供給するため保持部材23の内部に伝熱ガス供給管6を設けている。この伝熱ガスの圧力を制御することにより、半導体基板4と半導体基板載置面5との間の熱コンダクタンスを調節する。

【0017】冷却部材24の内部には冷媒流路7を形成し、外部に接続した冷却装置によって冷媒供給口8から冷媒を供給し、冷媒流路7を通り、冷媒排出口9から排出することにより冷却部材24を冷却する。プラズマ処理中に半導体基板4が受ける熱は、この冷却部材24を介して冷媒流路7の内部を流れる冷媒に逃がしている。

【0018】保持部材23と前記冷却部材24との間には、ガスを封入する伝熱ガス室26を設けてある。図2に示す実施例では冷却部材24の上面に凹みを入れることにより、保持部材23との間に伝熱ガス室26を形成している。なお、保持部材23と冷却部材24とは、伝熱ガス室26の外周部分、ブッシュピン28貫通穴の外側が溶接により接合されており、密閉空間となっている。保持部材23と冷却部材24を溶接で接合するた

め、この両者は金属により形成する。この伝熱ガス室26内に管27を通してヘリウムガスなどの気体を封入したり排出することにより、伝熱ガス室26内の圧力を制御し、これによって保持部材23と冷却部材24との間の熱コンダクタンスを調節する構造とする。

【0019】図3に、本発明の第2の実施例を示す吸着装置1の側断面の拡大図を示す。

【0020】この実施例では、保持部材23と冷却部材24とをボルト30によって機械的に固定している。冷却部材24に伝熱ガス室26の外周部分、ブッシュピン28貫通穴の外側に凹形状の溝を形成し、リング31により伝熱ガス室26内のガスが漏れないようにシールしている。実施例1と本実施例との違いは以下の点である。すなわち、半導体基板4を発熱体25により加熱する際には、保持部材23と冷却部材24とは温度、材質の違いから熱膨張による寸法変化量が異なる。しかしながら、保持部材23と冷却部材24とはボルト30によって機械的に固定しているだけなので両者の界面に応力は生じず、破壊する恐れは低い。また、先程述べたように、保持部材23と冷却部材24とは溶接による接合を行っていないので同様の材料を使用する必要はなく、自由に選択できる。例えば、高温に加熱される保持部材23はセラミックなどの耐熱性材料で製作し、冷却部材24は熱伝導率の高い金属材料で製作することができる。

【0021】図4に本発明の第3の実施例を示す吸着装置1の側断面の拡大図を示す。

【0022】この実施例では、半導体基板4の温度を測定するための温度計32を具備し、処理室内14に半導体基板4を搬入してから搬出するまでの間の、半導体基板4もしくは保持部材23の温度を計測し、外部に設置しているコントローラー（図示しない）に計測結果を伝えることができる。

【0023】ここで、成膜あるいはエッチングなどの半導体処理プロセスの初期における、半導体基板4の温度、および半導体処理プロセス中における半導体基板4の温度を、フィードバック制御によって管理することで、半導体基板4に、より高品質な半導体処理を行うことができる。

【0024】成膜あるいはエッチングなどのプロセスの初期温度を管理するためには、発熱体25による保持部材23の予備加熱中の温度制御が重要である。

【0025】例えば、発熱体25による保持部材23の予備加熱中に半導体基板4の温度上昇が遅ければ、半導体基板4と半導体基板載置面5との間のガスの圧力を上げることにより、温度が上がった半導体基板載置面5と半導体基板4との間の熱コンダクタンスが大きくなり、半導体基板4の温度上昇を速くすることができる。また、発熱体25の発熱量を上げることにより半導体基板載置面5の温度上昇を速くし、半導体基板4を温度上昇を速くすることができる。

【0029】逆に、成膜あるいはエッチングなどの半導体製造プロセス中に半導体基板温度の温度が高ければ、半導体基板4と半導体基板絶縁面5との間的气体の圧力を上げることにより、半導体基板4と半導体基板絶縁面5との間の熱コンダクタンスを上げ、半導体基板4の温度を低くすることできる。また、加熱室23と冷却部材24の間の熱コンダクタンスを上げ、保持部材23の温度を低くし、半導体基板4の温度を低くすることできる。

【0034】(1) 時間 $t_0$ に発熱体25を発熱させる。これにより、保持部材23の加熱を行うが、伝熱ガス室26内の圧力を処理室14と同じ数Pa程度にすることによって、伝熱ガス室26を通しての熱コンタクトをほとんど0にする。これにより、発熱体25による保持

部材23の加熱は、冷媒流路7へはほとんど影響しない。つまり、冷媒流路7の壁面温度はほとんど上昇しない。ここで、図6ではQ1を時間t0における立ち上げ時を除くt0'～t1'の時間帯で一定としているが、必ずしも一定である必要はなく、Q1をt0～t1'の間で変化させてもよい。

【0035】(2)処理室14に半導体基板4を搬入し、半導体基板載置面5に設置する。このとき、吸着用電極2および2'に給電し、半導体基板4を半導体基板載置面5に吸着させ、半導体基板4と半導体基板載置面5との間に、ヘリウムなどの伝熱ガスを流入させる。これにより、半導体基板4と半導体基板載置面5との間の熱コンダクタンスを上昇させ両者間の伝熱を良好に行わせ、半導体基板4の予備加熱を行う。ここで、図6ではQ1をt2における立ち下げ時を除くt1～t2の時間帯で一定としているが、必ずしも一定である必要はなく、Q1をt1～t2の間で変化させてもよい。

【0036】(3)伝熱ガス室26にヘリウムなどの伝熱ガスを流入、保持する。

【0037】(4)保持部材23内部の発熱体25の発熱を停止すると共に、処理室14内に処理ガスを導入し、プラズマ21を発生させて半導体基板4上に膜を堆積させる。前記(3)の動作で伝熱ガス室26にヘリウムなどの伝熱ガスを流入、保持した。これにより、伝熱ガス室26を通した保持部材23と冷却部材24との間の熱コンダクタンスを上昇させ、両者間の伝熱を良好に行い、冷却部材24を冷却することにより半導体基板載置面5の温度を下げ、T2を制御することができる。t2～t3の半導体基板載置面5の温度T1と半導体基板4の温度T2のグラフの実線曲線部分は本実施例を示すものであり、破線曲線部分は従来より行われているプラズマ処理を示す。従来の技術では、プラズマ処理初期におけるT1やT2が低く、プラズマ処理中の温度変化が大きいが、本発明の実施により、プラズマ処理中の温度変化を小さく抑えることができる。

【0038】ここで図6では、P1をt2における立ち上げ時を除くt2～t3の時間帯で一定としているが、必ずしも一定である必要はなく、P1をt2～t3の間で変化させてもよい。

【0039】(5)処理ガスの供給を止めてプラズマ21を消滅させ、プラズマ処理を終了する。

【0040】(6)プラズマ処理が終了した半導体基板4を処理室14の外に搬出する。また、伝熱ガス室26から伝熱ガスを排出し、圧力を処理室14と同じ数Pa程度にする。これにより、伝熱ガス室26を通した保持部材23と冷却部材24との間の熱コンダクタンスをほとんど0とし、両者間の伝熱量をほとんど0にする。

(7)時間t0'に発熱体25を発熱させ、保持部材23の加熱を行う。t0～t3までの処理によって、t0'におけるT1はt0におけるT1よりも高くなっているため、t

0'～t1'におけるQ1をt0～t1'のときよりも小さくして加熱を行う。ここで図6ではQ1をt0'における立ち上げ時を除くt0'～t1'の時間帯で一定としているが、必ずしも一定である必要はなく、Q1をt0'～t1'の間で変化させてもよい。また、t0'におけるT1が十分高く、t0'～t1'において被処理体載置面5を加熱する必要が無ければ、発熱体25による加熱を行わなくてもよい。

【0041】なお、前記(6)の動作によって伝熱ガス室26を通しての熱コンダクタンスはほとんど0である。これにより、発熱体25による保持部材23の加熱は、冷媒流路7へはほとんど影響しない。つまり冷媒流路7の壁面温度はほとんど上昇しない。

【0042】(8)処理室14に新たな半導体基板4を搬入し、半導体基板4を半導体基板載置面5に設置する。このとき、吸着用電極2および2'に給電し、半導体基板4を半導体基板載置面5に吸着させ、半導体基板4と半導体基板載置面5との間にヘリウムなどの伝熱ガスを流入させる。これにより、半導体基板4と半導体基板載置面5との間の熱コンダクタンスを上昇させ、両者間の伝熱を良好に行わせ、半導体基板4の予備加熱を行う。ここで図6ではQ1をt2'における立ち下げ時を除くt1'～t2'の時間帯で一定としているが、必ずしも一定である必要はなく、Q1をt1'～t2'の間で変化させてもよい。また、t0'におけるT1が十分高く、t0'～t1'において被処理体載置面5を加熱する必要が無ければ、発熱体25による加熱を行わなくてもよい。ここで半導体基板4の温度T2をt2およびt2'において等しく、つまり毎回の半導体処理プロセスにおいて、処理開始時のT2を等しくすることが重要である。

【0043】(9)伝熱ガス室26にヘリウムなどの伝熱ガスを流入、保持する。

【0044】(10)保持部材23内部の発熱体25の発熱を停止するとともに、処理室14内に処理ガスを導入し、プラズマ21を発生させて半導体基板4上に膜を堆積させる。前記(9)の動作で伝熱ガス室26にヘリウムなどの伝熱ガスを流入、保持したが、これにより伝熱ガス室26を通した保持部材23と冷却部材24との間の熱コンダクタンスを上昇させ、両者間の伝熱を良好に行い、冷却部材24を冷却することにより半導体基板載置面5の温度の制御を可能とし、T2を制御することができる。

【0045】ここで図6では、P1をt2'における立ち上げ時を除くt2'～t3'の時間帯で一定としているが、必ずしも一定である必要はなく、P1をt2'～t3'の間で変化させてもよい。

【0046】(11)処理ガスの供給を止めてプラズマ21を消滅させ、プラズマ処理を終了する。

【0047】(12)プラズマ処理が終了した半導体基板4を処理室14の外に搬出する。また、伝熱ガス室2

6から伝熱ガスを排出し、圧力を処理室14と同じ数Pa程度にする。これにより、伝熱ガス室26を通した保持部材23と冷却部材24との間の熱コンダクタンスをほとんど0とし、両者間の伝熱量をほとんど0にする以上説明した手順(7)~(12)をこの後に繰り返すことにより、半導体基板4を連続して処理することができる。なお、半導体基板4を連続して処理する場合、発熱体25の発熱量Q1、伝熱ガス室26内の圧力P1、半導体基板4と半導体基板載置面5との間に流入させるガス圧力、冷却部材中に流入させる冷媒の流量および温度は、毎回の処理プロセスにおいて同一のものをを用いることが最適とは限らない。また、本実施例で重要なのは、 $t_2 \sim t_3$ および $t_2' \sim t_3'$ におけるT2の変化を小さくすること及び $t_2 \sim t_3$ におけるT2を毎回の処理プロセスで再現させることであり、 $t_0 \sim t_3$ もしくは $t_0' \sim t_3'$ における発熱体25の発熱量Q1、伝熱ガス室26の圧力P1、保持部材23上面の温度T1は図6に示したものに限らない。

【0048】また、本実施例に示した半導体処理方法において、成膜あるいはエッチングなどの半導体処理プロセスの初期における半導体基板4の温度、および半導体処理プロセス中における半導体基板4の温度を、フィードバック制御によって管理することで、半導体基板4に、より高品質な半導体処理を行うことができる。

【0049】成膜あるいは、エッチングなどの半導体処理プロセスの初期の温度を管理するためには、 $t_0 \sim t_2$ もしくは $t_0' \sim t_2'$ にT2を管理することが重要である。

【0050】例えば、 $t_0 \sim t_2$ もしくは $t_0' \sim t_2'$ にT2の上昇が遅ければ、半導体基板4と半導体基板載置面5との間のガスの圧力を上げることにより、温度を上げた半導体基板載置面5と半導体基板4との間の熱コンダクタンスを大きくし、T2の上昇を速くすることができる。また、Q1を上げることにより半導体基板載置面5の温度上昇を速くし、半導体基板4を温度上昇を速くすることができる。

【0051】逆に $t_1 \sim t_2$ もしくは $t_1' \sim t_2'$ にT2の上昇が遅ければ、Q1を小さくすることによりT2の上昇を遅くすることができる。また、半導体基板4と半導体基板載置面5との間のガスの圧力を下げることで、温度が下がった半導体基板載置面5と半導体基板4との間の熱コンダクタンスを小さくし、T2の上昇を遅くすることができる。また、P1を上げることにより、保持部材23と冷却部材24との間の熱コンダクタンスを大きくし保持部材23の温度上昇を遅くし、T2の上昇を遅くすることができる。また、冷却部材24の内部に流入する冷媒の流量を上げる、冷却部材24内部に流入する冷媒の温度を下げるなどの制御によりT2の上昇を遅くすることができる。

【0052】また、 $t_1 \sim t_2$ もしくは $t_1' \sim t_2'$ にT2がオーバーシュートし、高くなったT2を下げる必要がある

場合は、Q1を小さく、あるいは0にし、P1を上げることで、保持部材23と冷却部材24との間の熱コンダクタンスを大きくしT1を下げ、その結果T2を下げることもできる。また、冷却部材24の内部に流入する冷媒の流量を上げる、冷却部材24内部に流入する冷媒の温度を下げるなどの制御によりT2を下げることもできる。

【0053】一方、 $t_2 \sim t_3$ もしくは $t_2' \sim t_3'$ にT2が低ければ、半導体基板4と半導体基板載置面5との間のガスの圧力を下げることで、半導体基板4と半導体基板載置面5との間の熱コンダクタンスが下がり、T2を高くすることができる。また、P1を下げることで、保持部材23と冷却部材24との間の熱コンダクタンスを下げる、T1を高くし、その結果T2を高くすることができる。また、冷却部材24の内部に流入する冷媒の流量を下げる、もしくは冷媒流路7に流入する冷媒の温度を下げることで、冷却部材24の温度を高くし、その結果、T2を高くすることができる。また、発熱体25を発熱させることによってもT2を高くすることができる。

【0054】逆に $t_2 \sim t_3$ もしくは $t_2' \sim t_3'$ にT2が高ければ、半導体基板4と半導体基板載置面5との間のガスの圧力を上げることにより、半導体基板4と半導体基板載置面5との間の熱コンダクタンスが上がり、T2を低くすることができる。また、P1を上げることで、保持部材23と冷却部材24との間の熱コンダクタンスを上げ、T1を低くし、その結果T2を低くすることができる。また、冷却部材24の内部に流入する冷媒の流量を上げる、もしくは冷媒流路7に流入する冷媒の温度を下げることで、冷却部材24の温度を低くし、その結果T2を低くすることができる。

【0055】ここではプラズマCVDを例にして処理方法を説明したが、これはプラズマCVDに限るものではなく、例えばプラズマエッチング、熱CVDなど、半導体製造の他の手段による処理に使用できることは言うまでもない。

【0056】

【発明の効果】以上説明したように本発明によれば、吸着装置を用いた半導体処理装置において、半導体基板を高温に予備加熱が可能であり、応答性の良い温度制御を半導体基板に行うことが可能な半導体処理装置を提供でき、また半導体基板に行う、優れた半導体処理方法を提供できる。

【図面の簡単な説明】

【図1】本発明の第1実施例を示す半導体処理装置の側断面図である。

【図2】本発明の第1実施例を示す半導体処理装置に使用されている吸着装置の側断面の拡大図である。

【図3】本発明の第2実施例を示す半導体処理装置に使用されている吸着装置の側断面の拡大図である。

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【図4】本発明の第3実施例を示す半導体処理装置に使用されている吸着装置の側断面の拡大図である。

【図5】本発明の第4実施例を示す半導体処理装置に使用されている吸着装置の側断面の拡大図である。

【図6】本発明の第5実施例を示す半導体処理方法を示すシーケンス図である。

【図7】吸着装置の従来例を示す側断面図である。

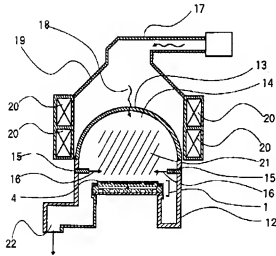
【符号の説明】

1…吸着装置、2…吸着用電極、3…絶縁材、4…半導体基板、5…半導体基板載置面、6…伝熱ガス供給管、\*10

\*7…冷媒流路、8…流体供給口、9…流体排出口、10…カバー、11…直流電源、12…側壁、13…石英蓋、14…処理室、15…ノズル、16…処理ガス、17…導波管、18…マイクロ波、19…放電管、20…コイル、21…プラズマ、22…排気口、23…保持部材、24…冷却部材、25…発熱体、26…伝熱ガス室、27…管、28…ブッシャーピン、29…ブッシャーピン導入管、30…ボルト、31…Oリング、32…温度計。

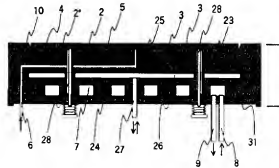
【図1】

図1



【図2】

図2

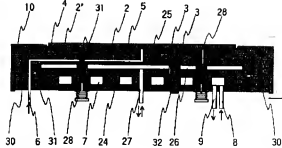
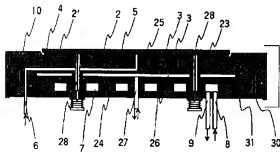


【図4】

図4

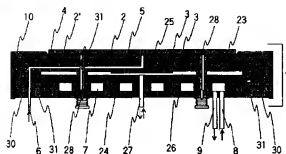
【図3】

図3



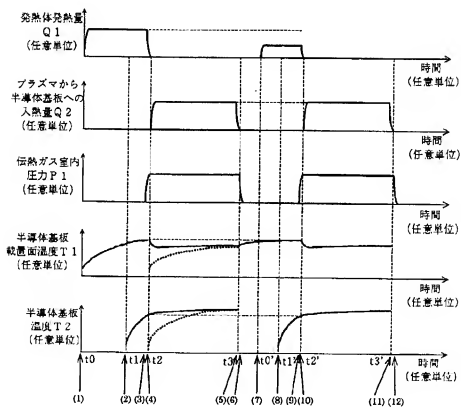
【図5】

図5



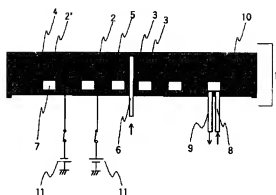
【図6】

図6



【図7】

図7



フロントページの続き

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F ターム(参考) SF004 AA16 BA15 BB11 BB18 BB22

BB26 BC08 CA04

SF031 CA02 HA16 HA23 HA37 HA38

HA40 MA28 MA32

SF045 AA08 DP03 EM05 EM07